A PLATFORM-INDEPENDENT PRODUCT LIBRARY FOR BIM

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ABSTRACT

There is considerable interest internationally in developing product libraries to support the use of BIM. Product library initiatives are driven by national bodies, manufacturers and private companies who see their potential. A major issue with the production and distribution of product information for BIM is that separate library objects need to be produced for all of the different software systems that are going to use the library. This increases the cost of populating product libraries and also increases the difficulty in maintaining consistency between the representations for the different software over time.

This paper describes a project which uses "software transformation" technology from the field of software engineering to support the definition of a single generic representation of a product which can then be automatically converted to the format required by receiving software. The paper covers the current state of implementation of the product library, the technology underlying the transformations for the currently supported software and the business model for creating a national library in Australia. This is placed within the context of other current product library systems to highlight the differences. The responsibilities of the various actors involved in supporting the product library are also discussed.

Keywords: product libraries, BIM, software engineering

1. INTRODUCTION

The fragmented nature of the construction industry is widely acknowledged (Egan, 1998; Johnson & Laepple, 2003; Latham, 1994). Model-based efforts to tackle interoperability problems, such as the IFCs and the BIM initiatives, are making significant inroads in industry. However, the success of BIM has lead to the recognition that user extensions to BIM to support product libraries are impeding interoperability.

It is estimated that there are around 20,000 design firms in the construction industry in Australia. There are many more that are involved further along the building procurement supply chain. Many of these firms, whether they are using 2D CAD or 3D BIM have their own in-house libraries to supplement their systems. While the major vendors of BIM software are international, their markets are segmented when considering localization of the object libraries that are supplied with the software. Issues that arise from this include:

- Significant duplication of effort and consequent industry wide inefficiencies;
- Scope of objects is restricted to the needs of the creating firm;
- Manufacturers data encoded in the objects may not be accurate or up to date;
- Disparities in the naming of objects and attributes and in the range of values used;
- Objects only applicable to the products from single vendors.

The recent high level of interest in product libraries internationally indicates that these issues are widespread globally.

2. SURVERY OF OBJECT LIBRARY INITIATIVES

Interest in product libraries is not new. Examples of previous research and implementation efforts include the ARROW project, CONNET-MPS and GEN Projects (Amor, Jain & Augenbroe, 2008) as well as research at the University of Auckland (Amor & Kloep, 2003) and University of Edinburgh (Ofluoglu, 2003) where accessibility to product information from manufacturers and beneficial ways of interacting with product information formed the research foci respectively. More recently, Murphy, McGovern & Pavia (2013) and Fleming, Long & Swindler (2012) explore new ways of utilising model information for Historic Building Information Modelling (HBIM) and the creation of energy models from online repositories.

Product Spec of New Zealand and the National BIM Library of the United Kingdom were selected as other examples of national product library initiatives which capture two different types of functionality. Product Spec is an example of a "traditional" manufacturer's product library, while the National BIM Library integrates products with additional services. The descriptions below are based on the systems as existing in June 2013. The Australian National Object Library (NOL) initiative presented in this paper is contrasted with this other work.

One of the criteria for comparison is the *level of definition* (LOD) as defined by the American Institute of Architects (Bedrick 2013). For building products, this can be summarized as LOD 200 indicates the approximate size and position of a product or construction type through increasing levels of detail to LOD 400, which is a fully detailed definition of the product/construction type to be installed. LOD 500 is reserved for a verified on-site installation.

2.1 Product Spec

Product spec (http://www.productspec.net/) serves as a national library of products in New Zealand with over 50,000 products in 22 main categories and 101 sub-categories. It contains over 12,500 CAD and BIM files for architecture, design and landscape products, with approximately 1400 of these are BIM files (Product Spec, 2013). The user interface is a standard web page where the user drills down through a hierarchy to access the product(s) of interest. The CAD/BIM file pages show a graphic that indicates the content. The user needs to choose the file format that matches their software at the top of the search. Consequently a user will not see files that are only available in another format without explicitly searching for them. It is difficult to assess how many products are stored in multiple formats.

Most of the files represent products from specific manufacturers at LOD 350-400.

2.2 The National BIM Library

The National BIM Library (http://www.nationalbimlibrary.com/) is a product of the National Building Specification (NBS) owned by the Royal Institute of British Architects (RIBA) in the UK. The library of products offers users free access to IFC-compliant content and the choice to download products in any one of five software formats according to system requirements and availability - Autodesk Revit, ArchiCAD, Vectorworks, Tekla and Bentley (NBS, 2013). Many products appear to only be available in IFC, Revit and Vectorworks formats. Beyond the usual product library service, the components of the National BIM Library are offered together with property set definitions integrated with the Uniclass tables of classification. Furthermore, users are given the option to browse the library according to two broad categories; by objects or by manufacturers. Consequently, access is provided to 28 product categories which cater to 709 objects as well as 155 proprietary objects derived from 9 manufacturers. Products from the library download in a zipped folder containing a user guide in PDF format, a text file for product-specific parameters as well as a text file of shared parameters in addition to a CAD/BIM file as modelled in the software environment selected by the user.

The files represent a range of LODs, from 200 for generic products through to specific manufacturer information at LOD 400. This is supported by the strong relationship between NBL and NBS Create. The NBL also provides direct support for the export of COBie data through its own user interface.

2.3 The Australian National Object Library.

The Australian National Object Library has broader ambitions than the previous two examples. The initial goal was to support a range of export formats from a single generic object description directly into the receiving software. This is to ensure that the same information about a product is inserted into each receiving software. This can not be guaranteed if objects are developed separately for each receiving software. Currently, Revit, ArchiCAD and Rhino, with GeometryGym add-ons, are supported. Work is underway to add support for Bentley AECOsim. Products are also supported at multiple LODs. Additional properties can be attached to an object from directly within the CAD system even after an object has been inserted. In order to achieve this goal, a wide range of software needs to be supported, including non-BIM software, such as MS Project or Primavera.

A key issue is also to provide a simple method for product manufacturers to directly add and update the details of their products, both for attributes/properties and geometry/visualization. This is driven by the belief that a full national product library will not be sustainable if the hosting organisation has to maintain all of the data.

A longer term goal is to support cradle-to-cradle life cycle of construction projects over a building's life span for the entire supply chain with information about a product type, from LOD 200 through to LOD 400, covering design and documentation, through construction to LOD 500 and then to support the facilities management process. The work to support this goal is still under development.

Figure **1** compares the properties imported into Revit from each of the libraries discussed above. The ProductSpec window has some basic properties. The BIM Library window is configurable in tis operation and has a long list of properties that are necessary to support the generation of a matching specification. Two windows are shown for the NOL window – one is the standard Revit properties window and the other is a custom properties window which groups properties under categories which can be collapsed to make viewing easier. A conscious decision was made for NOL objects to not be configurable. This supports the generation of drop-down lists in the NOL web browser. Figure **2** shows part of the property list for sliding windows where the height has been selected and the available values for the window width are displayed automatically.

Some other product libraries like Google's 3D Warehouse (Google, 2013) and Autodesk's SEEK (Autodesk, 2013), are freely available to users online, while others are accessible through subscriptions. Three of the more popular commercial product libraries are: AutoSpec (AutoSpec, 2013), Reed Construction Data (Reed, 2013), and McGraw Hill's Sweet Catalog (McGrawhill, 2013).

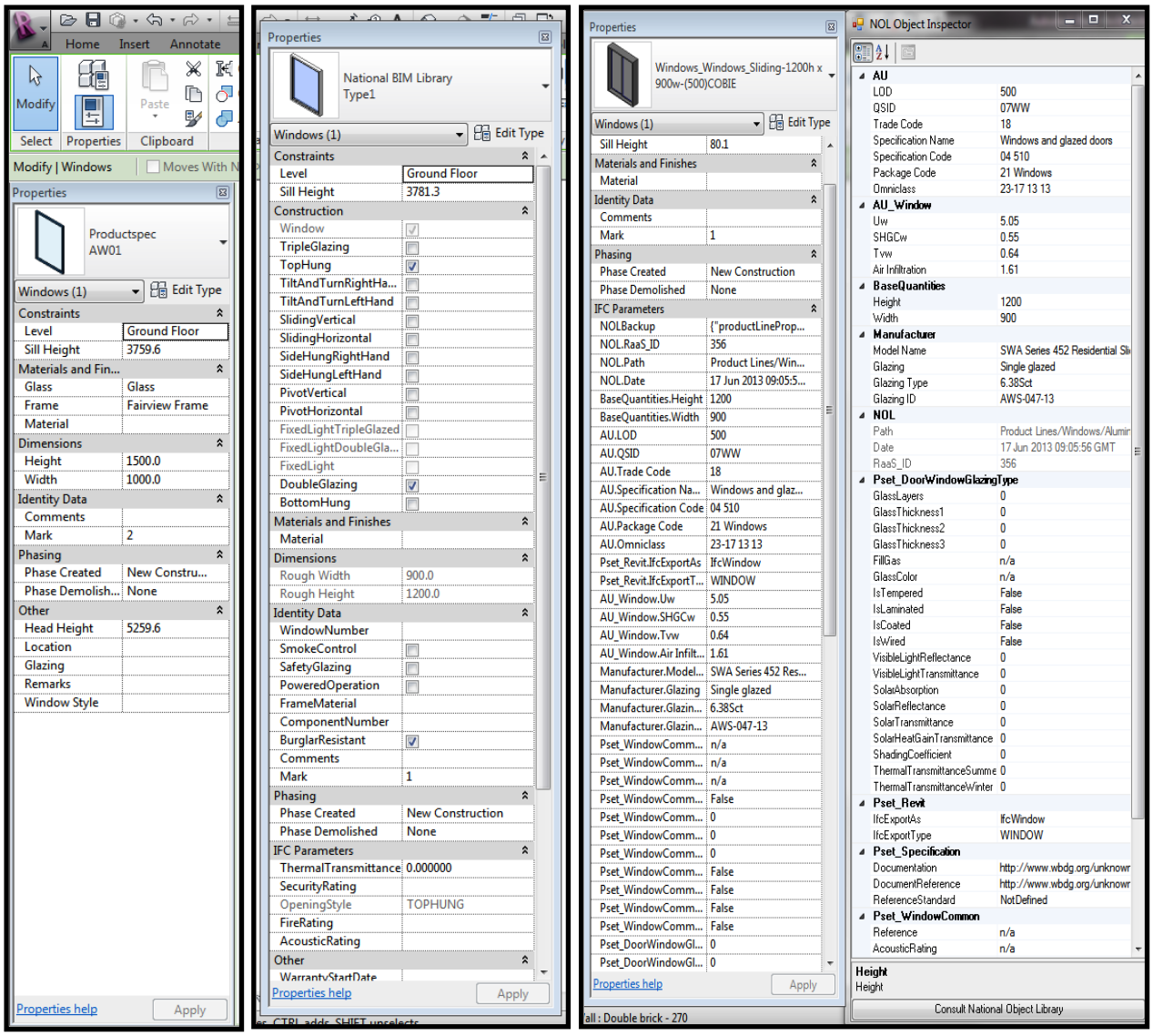

Figure 1: Comparison of window properties from (a) ProductSpec, (b) UK National BIM Library and (c) Australian NOL

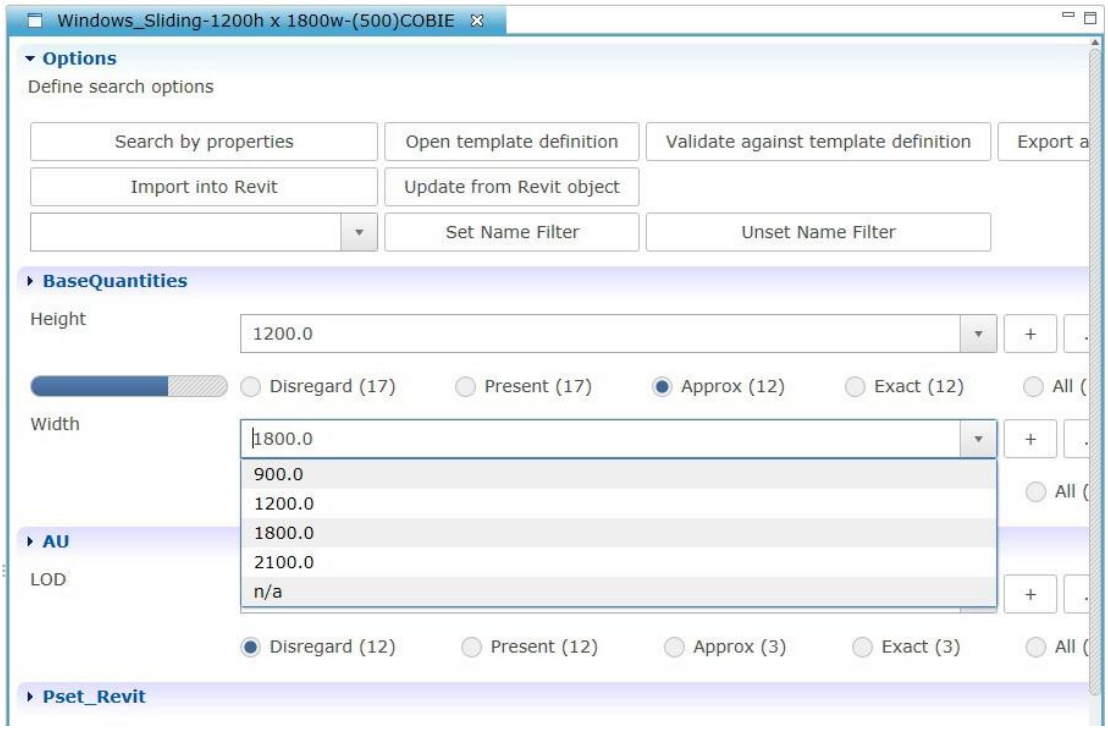

Figure 2: Drop-down lists in NOL property selection

3. REQUIREMENTS FOR AN AUSTRALASIAN OBJECT LIBRARY

The aims of the host project in which the Australian National Object Library (NOL) candidate is being produced are very broad, and encompass cradle-to-cradle life cycle of construction projects over a building's life span. The ultimate vision of using digital building models across tools and stakeholders, throughout the life and changing ownership and occupancy of the buildings that are constructed is still some way from realisation.

The scope of the National Object Library includes:

- The publication of templates for digital objects, including required properties, e.g. 'U' value, SHGC, etc., with ranges or choices of values, as well as geometry for use within digital design tools.
- The classification of digital objects according to multiple classification schemes relevant within various sectors of the Australian and international building industries.
- The ability for manufacturers of building products to fill in these templates to represent their products, and publish them to the Library. This includes the ability to upgrade and deprecate product descriptions, while retaining a record of any product actually deployed in a building for later use by the building owners and maintainers.
- The ability for designers and specifiers to browse or search the Library using various parameters to match products that meet their criteria, and to download the objects which describe them in formats that are suitable for the design and analysis software tools that they use.

Some things out of scope for the initial deployment are:

- Integration of the NOL with company or project specific libraries. This is planned for phase two of the project.
- The support for arbitrary parametric designs.

4. CONCEPT OF OPERATIONS

4.1 Roles and Actors

The main roles involved in the collaborative use of a National Object Library are:

- Manufacturers of products for supply to the Australian building industry.
- Designers who need product information, and objects for use within their digital designs.
- The Library, which can be thought of as three sub-roles:
  i. Developers of the Library infrastructure.
  ii. The Library Operator which manages the IT infrastructure on which the library runs, and its online interface(s) to the Manufacturers and Designers.
  iii. The Librarian, who acts as a gateway between publishers of objects and the collection available to Designers, and provides quality assurance

4.2 Manufacturers

With respect to the National Object Library, the role of "Manufacturer" is quite simple. These stakeholders simply locate the right template for the kind of product they supply to the construction industry, fill in the properties with values, ranges or alternatives that correctly represent their products, and optionally upload an IFC file with its geometry. However, the reality of the industry is that this role may need to be played by a large range of actual companies, ranging from the very small local specialist in a particular material, to large multi-national companies which make vast ranges of building products using their own digital design and manufacturing tools and methods.

4.3 Designers

In stage 1 of development of the NOL each building product is described by a unique object, which can be located by smart searching, and then downloaded in a format suitable for the CAD tool of choice. In reality, products come in product lines and are combined into product systems, which have some fixed properties, but many variables, some of which are dependent on one another. Additionally, not all design processes allow for fully specified products to be included in designs, especially at early phases. In particular, large projects involving tendering and contracting must allow for certain degrees of freedom and fully specified properties may only be chosen late in design to match the aesthetic or engineering requirements that are not known in early design.

There may also be several people with different design roles in large project teams, all of whom may need some input into the choices of properties for objects in their design, which are only later matched with real manufactured products. However, smaller practices which manage whole projects may have prefered suppliers and versions of products that they wish to use in full detail as soon as they are added to the design.

The NOL envisages an iterative process of design in which more and more becomes known about the requirements for a product during the process. There will be a continuum of generic to specific in the selection of products, and of the specification of detailed properties of the products. Some scenarios for use of objects and their property sets from the NOL are outlined in Duddy *et al* (2012).

4.4 Library

The actual product library will be an internet-accessible computer system containing a repository of product definitions, templates for new product definitions, and a number of categorisation mechanisms and search facilities for various kinds of users to allow ease of discovery of templates and product definitions. In addition, it will provide transformations of product definitions into the native formats of a number of CAD and CAE applications, as well as the standard interchange format IFC.

4.5 Developers

Development was conducted by Sustainable Built Environment nrc and its partner organisations, including major contributions by QUT, Smart Services CRC, and the now defunct Queensland Government's Project Services

agency. CAD vendors are also being invited to provide implementation support and guidance with respect to the best possible integration of their existing object library mechanisms with the NOL.

In addition to delivering software that can store and retrieve building product templates and descriptions, there has been initial content developed by the SBE partners, including templates for major product types, and a framework for categorising the templates and the product descriptions based on them. The Developers also worked with as many product manufacturers as possible to complete example product descriptions and their placement in the relevant category frameworks supported by the Library.

Once deployed, the Library Operator will need to continue doing maintenance and bug fixes. However, the majority of development work for a proposed Stage 2 of the Object Library will deal with the representation and storage of parametric objects and product lines.

4.6 Library Operator

In addition to hosting or out-sourcing the computing servers where the Object Library runs, the Operator will also need to provide staff to conduct industry liaisons, education and training, perhaps in cooperation with other design and construction industry peak bodies. Given the limited knowledge of digital design by a some portion of building industry manufacturers, the Operator will also need to provide services, or coordinate the delivery of services, to model products on behalf of manufacturers for upload into the Library.

4.7 Librarian

The Librarian is a person, or people, who work for the Operator and/or delegated industry peak bodies, who is responsible for approval of product descriptions before publication to the NOL. There will be a special interface to the Library for the Librarian role, and some software to assist in checking for some technical aspects of submitted descriptions. However, the Librarian will need to apply his or her experience and judgement to assess both the quality and completeness of the content of the submitted product descriptions, and the categories in which the product is to be placed. It is also possible that the Librarian may apply additional categorisation to the submitted product descriptions, also perhaps with some software support.

4.8 Supported Processes

There are several processes that will be supported by the NOL for submission, publication, search and download of product templates and definitions over time.

The processes, most involving several roles that make up the end-to-end definition and use of the Library are as follows:

- Registration of a User into a role in the Library
- Update of a User registration
- Submission and publication of a Product Template
- Submission and publication of Product Description
- Search and download of a (set of) Product Template(s)
- Search and download of a (set of) Product Description(s)
- Date range searching for deprecated Product Descriptions
- Submission and publication of a superseding Product Template
- Submission and publication of a superseding Product Description
- Deprecation of Product Template
- Deprecation of a Product Description

This paper allows space for one example process to be shown: Submission and publication of Product Description. The BPMN Notation allows for each role to be represented as a separate “swim lane”.

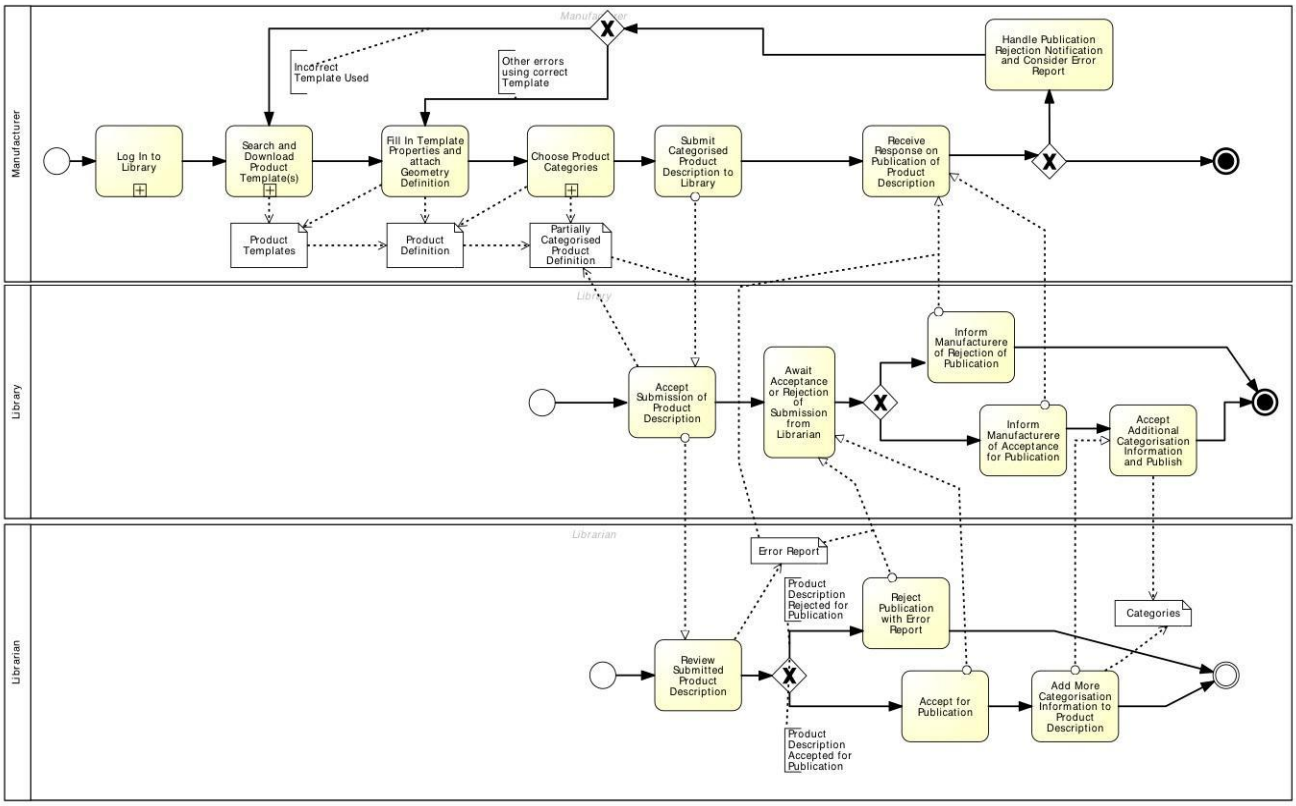

Figure 3: Submission and Publication of a Product Description

A Manufacturer (shown in Figure **3** as the top "swimlane"), or their digital design proxy, will be able to populate a Product Template of the appropriate type with values, ranges or choices for properties, and geometry descriptions in the Library (shown as the middle swimlane), with approval and extra metadata from the Librarian (shown in the bottom swimlane).

The process is as follows:

- Manufacturer logs in to the Library
- Manufacturer employs the "Search and download of a (set of) Product Template(s)" process to download the appropriate template from the library
- Manufacturer fills in the properties of template with values, choices of values or ranges which describe the product, and attach (potentially simple parametric) geometry definition.
- Manufacturer chooses categories in which the Product Definition should appear in one or more categorisation systems supported by the Library.
- Manufacturer submits the Product Description to the Library.
- Librarian reviews the submitted Product Description, potentially passing it back to Manufacturer with error report and/or comments and queries (Back to Step 2).
- Librarian applies additional categories to the Product Definition.
- Librarian publishes Product Definition to Library.

5. SOFTWARE IMPLEMENTATION

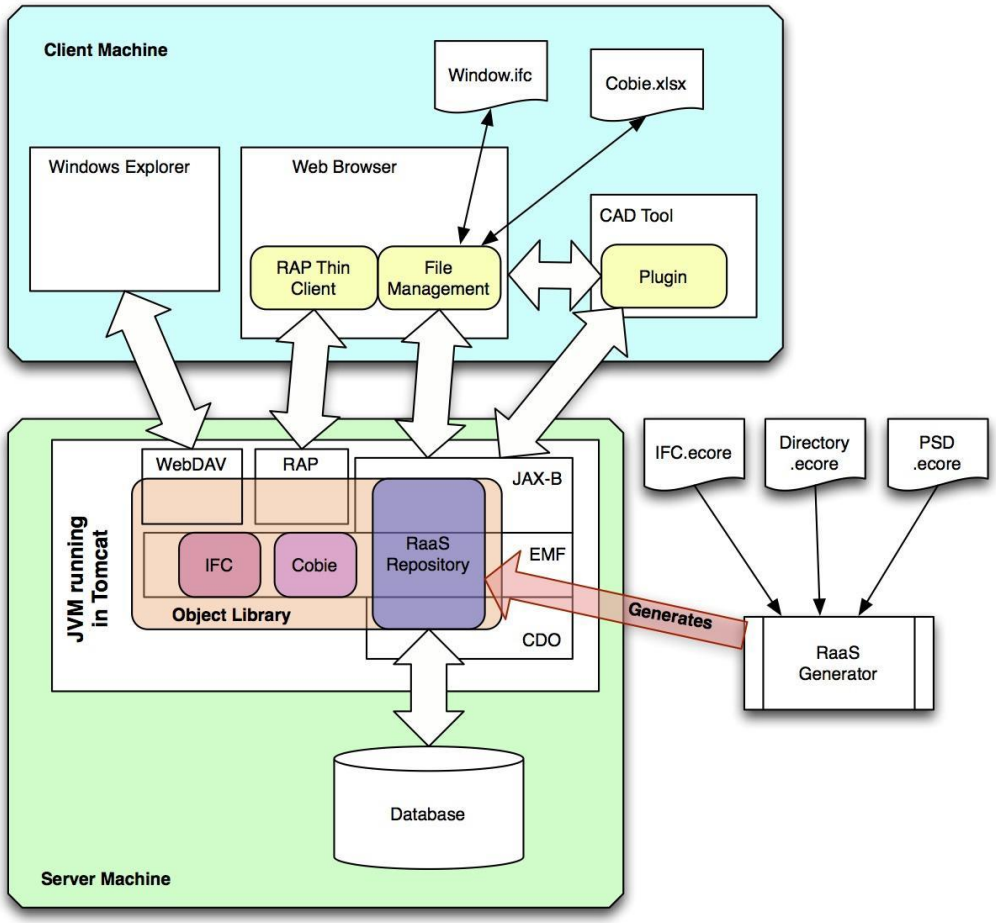

Figure 4: Detailed Software Architecture Visualisation

5.1 Object Library Server

The server implementation is shown as a set of nested coloured boxes representing software components overlaid on top of the frameworks that they use. The outermost container is Apache Tomcat. JVM is the Java Virtual Machine that executes the whole NOL server, which is packaged as a Web Archive (.war) file. The "stack" of libraries that are used to host the repository of building product objects are: JAX-B, which handles Web services requests and replies from clients on the internet; EMF, the Eclipse Modelling Framework, which hosts the objects in computer memory, and allows Java code to search over the objects, to transform them into polygon-based representations, and provides code that reacts to the user when they do things to the Web-browser interface; and CDO, Connected Data Objects, an Eclipse plugin that manages how these objects are saved and loaded from the "Database", which can be seen below the Tomcat box.

5.2 Raas Repositories

RaaS stands for "Repository as a Service", which is a tool to generate code that hosts the repository of building products using the three aforementioned frameworks: JAX-B, EMF and CDO. The "Raas Generator", shown on the right hand side of Figure **4** is a way of using the schemas (or metamodels as they are called in EMF) of the information that we need to store to generate Java code and annotations to that code that instruct the three frameworks how to generate additional code in turn. The novelty of RaaS is that it marries together a way of

storing and retrieving model objects into a database with a way of exposing groups of objects to remote client software via Web services.

CDO assists RaaS in managing which objects are in the database, and which are in memory without the programmer needing to write explicit code to store and retrieve them. The programmer writes code as if all objects are in memory all the time, and the CDO framework intelligently reads and writes them to the database in a safe way so that no state is lost, and in an efficient way so that only a few megabytes of memory is used to represent many gigabytes of actual objects, and that those objects most used are always available in memory, while those least used are retrieved from in the database as needed.

The "ecore" files that are shown as inputs to the RaaS Generator are annotated to indicate which object types are grouped together as domain entities. We use this concept, for example, when transmitting pieces of IFC geometry to clients such as the Revit Plugin that translates the IFC into native Revit objects. The RaaS generates code to transmit all objects that describe a product's geometry (which may range from a handful, to many thousand objects), all in a single interaction, rather than making the client code request each object separately.

5.3 EMF Resource Implementation

The way that EMF is used to load models that are stored in files (like XML, XLS, and IFC files) is by using so-called "resource implementations", which read the files, and produce in-memory EMF model graphs. These are then passed over to RaaS for management as CDO databases and/or Web service-accessible domain entities. The pink IFC and COBie components show in Figure **4** allow for the reading and writing of ".ifc" (Part 21) files, and .xlsx (COBie spread sheet) files into and out of EMF object graphs. These components are used indirectly by the File Management part of the user interface to allow users to get access to Library Object information in standard file formats, and to upload new Object definitions into the Library.

5.4 RAP Thin Client

This is a partially-generated user interface created in the Eclipse Rich Application Protocol (RAP) framework that is loaded into a web browser, and shows the user a customised version of the Eclipse IDE as a remote client. Its purpose is to display the contents of the Library, and allow for searching and display of the details of Objects in the Library.

In our user interface configuration shown in Figure 3 these include (left to right): listings of the folder hierarchy of Objects over a search results listing, detailed properties of a selected Object, and an interactive 3D preview of the Object's geometry. In addition, there are drop-down menus for managing files and window configurations, and a "ribbon" of popular kinds of objects for easy searching by category.

6. CONCLUSION AND FURTHER WORK

A new type of implementation of product libraries has been described which provides a single definitive definition of the attributes and geometry of products which is then "mapped" to the format expected by the receiving software. This provides a level of consistency which is required for large groups of products to be maintained in a consistent manner. The roles proposed for the various actors who are involved in providing product libraries are also described for the current implementation.

Further work is currently underway to:

- support software used further down the supply chain;
- support the concept of "project libraries" which would allow users to adapt manufacturer defined objects to the specific requirements of a project; and
- allow the use of parameters in a limited way within product definitions.

ACKNOWLEDGMENTS

The work described in this paper was supported by the Sustainable Built Environment National Research Centre and the Smart Services Cooperative Research Centre. Significant contributions were made by staff from the Queensland government Project Services and NATSPEC.

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